Instructions on Application of Traffic Analysis Tools

Introduction

The Utah Department of Transportation (Department) has used of a variety of traffic software tools in the development of the I-15 Corridor Expansion Project (Project). These tools each have their appropriate application and, when utilized collectively, are useful in the development of detailed design and maintenance of traffic concepts.

The regional travel demand model (TDM) operates at the macroscopic level to determine traffic flow for the entire Wasatch Front region. When the TDM is modified and run to represent a scenario, changes in daily trip patterns are recorded and traffic can be evaluated between scenarios.

Mesoscopic models can be used to gain further insight into peak hour impacts. The model can utilize outputs derived from the regional TDM on an identical zonal basis. The direct correlation provides a way to apply trip tables' differences between scenarios directly to a peak hour, which the mesoscopic models then output as intersection turning movement volumes. Further, outputs from the mesoscopic models can be applied to even more detailed models to further investigate the impacts of construction.

Similar to the correlation between scenarios in the demand trip tables, differences in turning movements from the mesoscopic model can be applied to collected field data that is utilized by other microscopic traffic software. Microscopic software is beneficial for detailed improvements such as updating signal timing and turn bay capacity.

The purpose of this document is to establish requirements and expectations for traffic analysis on the Project.

Required Traffic Software

It is important that all of the traffic analysis performed on the Project be consistent and that the tools used are applied appropriately. This requirement applies to all phases of the project, including preliminary design, proposal development, and final design/construction. To accomplish this, and to simplify the review process, the Department requires that the Contractor use the software versions listed in Table 1 for traffic analysis for the Project. Traffic modeling in software other than those listed in Table 1 will not be considered without prior approval.

Table 1: Traffic Software Required for Use on the Project

Analysis Type	Software Creator	Software Name	Software Version
Group 1: Travel demand forecasting and Macro-scale (mesoscopic) simulation software			
Travel demand forecasting	Citilabs	CUBE 5 Forecasting Suite (Cube Base and Cube Voyager modules)	5
		WFRC / MAG regional travel demand model as modified for the Project	6.0

Macro-scale (Mesoscopic) simulation	Quadstone	Quadstone Paramics	6.5.3
Group 2: Traffic modeling software			
Analytical / deterministic analysis	McTrans	HCS+	5.21
Analytical / deterministic analysis	Trafficware	Synchro Studio (Synchro module)	7
Microscopic simulation	PTV America	VISSIM	5.10-06

Use of Traffic Models Provided to the Contractor

A number of traffic models were produced by the CORE Team in the development of the Project and have been provided to the Contractor. Some of these traffic models are required to be used by the Contractor, and some are provided for informational purposes only. The models that are required for use by the Contractor have modification restrictions on them, as described in this document. The purpose of these restrictions is to keep the modeling efforts of the Contractor consistent, to allow direct comparison of the modeling results, and to simplify the review process.

Table 2 is a summary of traffic models provided by the CORE Team that are required for use by the Contractor. These models are found in RFP Part Six: Engineering Data.

Table 2: Traffic Models Provided to the Contractor Required for Use on the Project

Software	Year	Description	Notes
CUBE	2008	WFRC/MAG Regional TDM	Version 6.0
CUBE	2010	WFRC/MAG Regional TDM	Version 6.0
CUBE	2015	WFRC/MAG Regional TDM	Version 6.0
CUBE	2020	WFRC/MAG Regional TDM	Version 6.0
CUBE	2030	No-Build WFRC/MAG Regional TDM	Version 6.0
CUBE	2030	Build WFRC/MAG Regional TDM	Version 6.0
Quadstone Paramics	2008	AM Peak I-15 CORE macro-scale simulation model	Version 6.5.3
Quadstone Paramics	2008	PM Peak I-15 CORE macro-scale simulation model	Version 6.5.3

All other models provided to the Contractor by the CORE Team and not listed in Table 2 are for information only. These models may be used by the Contractor at its discretion in the development of alternative concepts. Newly developed models must conform to the requirements of this document.

Past and Future Use of Traffic Software Tools

Table 3 summarizes the past and future use of these tools by UDOT, and UDOT's requirements for their use by the Contractor.

Table 3: Past and Future Use of Traffic Software Tools

Software	UDOT's Past and Future Use	Use by Contractor
Group 1: Travel demand forecasting and mesoscopic simulation software		
1 – CUBE 5, and 2 – WFRC/MAG regional travel demand model ver. 6.0	PAST USE: Development of I-15 CORE-specific version of regional travel demand model (TAZ structure, socioeconomic data, Access Utah County projects included) Development of intersection turning movements (using NCHRP 255 methods) Development of tools for extracting subarea trip tables for use in Paramics, and preparation of trip tables Screening of conceptual MOT plans INTENDED FUTURE USE: Evaluation of proposed 2030 improvements	Screening of scenarios to test MOT plans involving changes in: - Mainline capacity for extended periods of time - Access to and from the mainline - Time of day variations in access or capacity (off-peak closures) - Local network capacity for extended periods of time Development of project scope to maximize regional mobility
3 – Quadstone Paramics ver. 6.5.3	PAST USE: Development and calibration of peak hour existing conditions (2008) model covering I-15 and major alternative routes Development and evaluation of scenarios to test conceptual MOT plans INTENDED FUTURE USE: Evaluation of proposed MOT plans	Development of MOT plans that maximize regional mobility. Test changes involving: - Intersection geometry (including lane closures) - Interchange geometry (including lane, ramp, and cross street closures) - Mainline capacity - Signal timing and phasing in arterial corridors - Access across the mainline at a single location Development of intersection turning movements

Group 2: Traffic modeling software		
4 – HCS+ ver. 5.21	PAST USE: Evaluation of conceptual designs Analysis for I-15 CORE Access Justification Report INTENDED FUTURE USE: Evaluation of revised AJR (if necessary)	Screening of new design concepts involving: - Basic freeway segments - Weaving areas - Ramp junctions Preparation of revised AJR (if necessary)
5 – Synchro Studio 7, Synchro module	PAST USE: Data storage for existing conditions (2008) geometry Data storage for existing conditions AM and PM peak period traffic signal timing Data storage for existing conditions AM and PM peak hour volumes Evaluation of design concepts Analysis for I-15 CORE Access Justification Report INTENDED FUTURE USE: Evaluation of proposed signal timing plans Evaluation of revised AJR (if necessary)	Development of signal timing plans for use in VISSIM Preparation of signal timing plans for arterial traffic signal operations on state routes during construction Preparation of revised AJR (if necessary)

6 – VISSIM ver. 5.10-06	PAST USE: Evaluation of proposed design concepts Analysis for I-15 CORE Access Justification Report INTENDED FUTURE USE: Evaluation of proposed design concepts Evaluation of revised AJR (if necessary)	Preparation of new design concepts involving: - Weaving areas, ramp junctions, ramps, and ramp termini - Interactions between closely spaced intersections - Ramp metering impacts - Mainline analysis of northern and southern termini and mainline configurations differing from the UIC - Queuing and turn bay / storage length Preparation of revised AJR (if necessary) Preparation of video animations

The proposals are required to include VISSIM models for key locations defined in the RFP and for interchange (interchanges include all ramp junctions, ramps, ramp termini, and cross streets) and mainline design concepts that differ from the Ultimate Infrastructure Configuration (UIC). The UIC is defined in the RFP. UDOT encourages the Contractor to involve I-15 CORE traffic personnel as early and as frequently as needed during proposal preparation to ensure mutual understanding of traffic issues and traffic modeling requirements in the corridor. UDOT encourages the Contractor to consider FHWA's requirements with regards to any proposed changes in access in the project corridor.

The remainder of this document provides information about available traffic data and modeling references and detailed instructions about the application of these traffic software packages. This document is intended to provide the Contractor a common set of rules to follow as they prepare MOT plans and design concepts for their proposals.

Available Traffic Data and Modeling References

Table 4 summarizes traffic data that has been provided to the Contractor.

Table 4: Available Traffic Data

Data Item	Source	Coverage
Supplied in RFP		
1. 2008 AM and PM Peak Hour Volumes (PDF files)	I-15 CORE Team	I-15 CORE corridor – mainline, ramps, interchanges and adjacent intersections

2. 2030 AM and PM Peak Hour Volumes (PDF files)	I-15 CORE Team	I-15 CORE corridor – mainline, ramps, interchanges and adjacent intersections
3. I-15 and arterial raw data from travel time runs – lat-long coordinates collected at 2-second intervals; multiple runs on various facilities collected during the AM and PM peak periods	UDOT TOC	I-15: Exit 248 to Exit 288 SR-73 (Lehi Main Street): Lehi 400 West to US 89 US-89 (State Street): Center Street Provo to Center Street Orem SR-265 (University Parkway): UPRR overpass to 900 East
4. I-15 and arterial travel time summarized data – AM and PM peak periods – Average travel time on defined segments	I-15 CORE Team	I-15: Exit-to-exit average travel time on 19 segments SR-73 (Lehi Main Street): Average travel time on 8 segments US-89 (State Street): Average travel time on 7 segments SR-265 (University Parkway): Average travel time on 10 segments
Other		
5. Performance Monitoring System (PeMS) – archive of UDOT's ATMS data	UDOT TOC	UDOT's entire ATMS
6. Traffic on Utah Highways Reports – Directional AADT for past years	UDOT Systems Planning and Programming Division	State routes throughout Utah

Table 5 summarizes a number of references about travel demand modeling and traffic modeling with which the Contractor should be familiar.

Table 5: Traffic Modeling References

Document Title	Publisher	Document Date
Utah Division Change in Access Procedure	FHWA Utah Division	October 2008
Utah Travel Demand Forecasting	UDOT	July 2008
Highway Capacity Manual 2000 (2nd Printing)	Transportation Research Board	July 2005
Traffic Analysis Toolbox, Volume III: Guidelines for Applying Traffic Microsimulation Modeling Software	FHWA	July 2004

NCHRP Report 255: Highway Traffic Data for Urbanized Area Project Planning and Design	Transportation Research Board	December 1982

The I-15 CORE Access Justification Report is included in the Informational Documents section of the RFP.

Instructions for Application of CUBE 5 / Regional TDM V6.0

It is assumed that the user currently has a working version of the WFRC/MAG v6.0 model. The user should have an executed agreement with WFRC/MAG for the use of the v6.0 model. The I-15 CORE team has provided to the Contractor all necessary input files required to run the years 2008, 2010, 2015, 2020, and 2030. These instructions will outline how to setup the files to perform the desired model run. It is assumed throughout this section that a CD containing the I-15 CORE input files is located in the E:\ drive.

Modification Restrictions for the CUBE 5 / Regional TDM

Files in **E:\Regional TDM V60 Inputs** shall not be modified, with the following exceptions:

- The master network (MASTER_062408_I15.net) shall be updated for alternative scenarios along the I-15 corridor only. No other modifications to the master network are allowed.
- The transit line files in (3bModeChoice_Lin_HOV_network) may be modified as necessary in conjunction with master network changes.
- 1ControlCenter.txt files also may be modified as necessary; however, the demographic file references for each model year shall not be changed.

File Locations

1Controlcenter.txt examples have been provided for each year in the **E:\Regional TDM V60 Inputs** directory. These files assume the following file structure on the user's computer.

- The Parent Directory (which contains the WFRC/MAG v6.0 model) in **C:\V60_I15**
- Model inputs (all files in E:\Regional TDM V60 Inputs\) are copied to **C:\ModelTools\V60_InputsNotInParentDir\I15**
- Batch files are copied from **E:\HailMary Batch Files** to **C:\V60_I15**

Script Update

The “4AssignHwy_ManagedLanes.s” script was slightly modified. It must be copied from E:\UpdatedScripts\ to C:\V60_I15\4AssignHwy\As\ before running the model. Also, copy “4pd_mainbody_managedlanes.block” from E:\Updated Scripts\ toC:\V60_I15\4AssignHwy\As\block\ before running the model.

Base Variables

Table 6 lists the variables for lanes and functional type used in the master network as the base conditions for each year:

Table 6: Base Variables

Year	Network Lane Variable	Functional Type Variable
2008	LN_I15_08	FT_I15_08
2010	LN_I15_10	FT_I15_10

2015	LNI15_15D5	FTI15_15D5
2020	LNI15_20D5	FTI15_20D5
2030 I-15 Build	LN30_I15D5	FT30_I15D5
2030 I-15 No Build	LN30_I15NB	FT30_I15NB

Running the Model

1. Copy the appropriate 1Controlcenter_YEAR.txt (see table below) from **E:\Regional TDM V60 Inputs** to **C:\V60_I15\1Controlcenter.txt**

2. Run **C:\V60_I15\HailMary_Voyager_Pre-Processing.bat**

3. Append the appropriate turn penalty file (see table below)

from **E:\Regional TDM V60 Inputs**

to **C:\V60_I15\0b_NetworkProcessing\No\turnpenalties.txt**

4. Run **C:\V60_I15\HailMary_Voyager_After_Pre-Processing.bat**

See Table 7 for a list and description of key files:

Table 7: File Descriptions

File Name	Description
1ControlCenter_2008.txt	Example 1ControlCenter.txt for 2008
1ControlCenter_2010.txt	Example 1ControlCenter.txt for 2010
1ControlCenter_2015_D5.txt	Example 1ControlCenter.txt for 2015
1ControlCenter_2020_D5.txt	Example 1ControlCenter.txt for 2020
1ControlCenter_2030_D5.txt	Example 1ControlCenter.txt for 2030 I-15 Build
1ControlCenter_2030_NB.txt	Example 1ControlCenter.txt for 2030 I-15 No-Build
Add_to_turnpenalties_2008.txt	Append to “turnpenalties.txt” for 2008 models
Add_to_turnpenalties_2010.txt	Append to “turnpenalties.txt” for 2010 models
Add_to_turnpenalties_2015+.txt	Append to “turnpenalties.txt” for 2015, 2020, and 2030 models

The methodology for generating intersection turn volumes from the regional TDM generally follows Chapter Eight of the National Cooperative Highway Research Program (NCHRP) Report 255 as described in the UDOT document “Utah Travel Demand Forecasting.” This procedure as it was applied to the I-15 CORE Project is discussed below.

Three volume types are required to generate design year turn movement volumes: Actual base year counts, base year Travel Demand Model (TDM) volumes, and design year TDM volumes. Existing turn volumes for AM and PM peak hours were collected in 2008 as part of the I-15 CORE project. This data is contained in a separate tech memo. A base year, 2008, model was created for comparison with the existing count data. Figures are attached that show the 2008 model raw AWDT’s, and AM and PM peak hour volumes. The design year TDM volumes can be obtained from the model run for 2030 or from an interim year such as 2015 or 2020.

The WFRC/MAG model forecasts volumes for a 3-Hour AM period and a 3-Hour PM period. These volumes were converted to a 1-Hour by applying a 0.37 factor to the 3-Hour volume.

NCHRP Report 255 outlines three procedures to develop forecasts: A ratio method, a difference method, and a combined method. The difference method shall be used in the I-15 CORE project. This was chosen over the ratio method because when volumes are low, the ratio can be very large and have a greater potential to magnify any errors. The difference method uses the following formula:

Design Year Forecast = 2008 Count – 2008 TDM Volume + Design Year TDM Volume

Design year forecasts are to be calculated for each intersection approach and exit. Incoming and outgoing volumes at an intersection must balance, so engineering judgment must be used to assess whether the volumes are realistic. Once the approach and exit volumes are obtained, the turn movement volumes can be generated using the NCHRP255 procedure. A description of this method is beyond the scope of this report, but a free software program is available from http://www.dowlinginc.com/downloads.php that applies the methodology.

Please see the appendix for more detailed documentation of the development and application of the I-15 CORE regional TDM.

Instructions for Application of Quadstone Paramics

As part of the Maintenance of Traffic portion of the I-15 CORE project, UDOT developed a traffic simulation model using Quadstone Paramics. The Paramics model utilizes trip tables derived from the WFRC / MAG Regional Travel Demand Model (TDM) to simulate traffic conditions during the morning and evening peak hours. The Paramics model includes I-15 from south of the South Payson interchange (mile post 248), to north of the 12300 S interchange (MP 291). The model includes major arterial roads between Spanish Fork and American Fork. The following sections describe model properties, model modification restrictions, and how to prepare subarea trip tables from the regional TDM.

Model Properties

The following section summarizes assumptions made during the calibration phase of the model development.

Intersections

Since the Paramics models are at the mesoscopic level, only major intersections in the local network have intersection geometrics that match field conditions. However, dual left turns overlap through phases at specific high volume locations with dual left turn lanes. This assumes that left turning vehicle demand is accommodated by the protected left turn phase of the signal. Signal timings are approximate to mimic control delay and develop platoons.

Several intersections throughout the model are coded with green for all movements at the same time. This ensures that traffic can access the network and complete their trip. Note that not all loading points represent exact intersection and/or driveway locations in the field.

Volumes

The volumes used in the Paramics models are developed by the demand model and the peak periods are incorporated into the Paramics model. To match field data, exterior network loading points were adjusted through a fratar algorithm.

A Paramics simulation begins without any volume in the network. Operational issues do not accurately occur until the model has sufficient time to release volume to the network and "warm up." The first hour of simulation time is considered the model warm up. Any operational issues that occur during this first hour are generally dismissed.

The AM volume demand is set at 100%. This represents 35% of the 3-hour peak period. The PM volume demand is set at 94%. This represents 33% of the 3-hour peak period.

Vehicles

There are three sets of vehicles represented in the model: 1) HOV eligible, 2) General Purpose, and 3) Trucks. Each vehicle type is assigned to a respective trip table. There are ten vehicle types within each of the general purpose and HOV eligible vehicles. There are two trucks: a single trailer and a double trailer. The non-truck vehicles have a perturbation set to 5 and 98% familiarity. Trucks are 100% familiar.

Decision Groups

The decision group plug-in of Paramics was utilized to control routing. Paramics has a specific section in the information browser to inform the user that the plug-in is operating correctly.

Decision groups were applied where mainline vehicles would exit the facility and then re-enter the facility at an interchange. A location where decision groups were effective was bypass lanes of roundabouts. Since the decision group is an origin-destination based plug-in, route control to specific areas of the model could be addressed. The plug-in is also uses a percentage split, therefore allowing the user to control approximately how many vehicles use an alternative route.

HOV Lanes

The I-15 Corridor within the limits of the MOT model includes one high occupancy vehicle (HOV) lane in specific locations. The Paramics models have incorporated a separate facility for HOV lane eligible vehicles. This separate facility runs linear with the general-purpose facility. The entrance and exit sections of the separate HOV facility mimic field conditions. Restrictions control the use of the HOV lane to strictly HOV eligible vehicles. This restriction prohibited any general purpose and truck traffic from utilizing the lane.

Calibration Measures

The network was calibrated using link cost factors to control vehicle routes. The Paramics models were compared to existing travel times and volumes. Travel time governed calibration for the local arterial network, while travel time and volumes were used to calibrate the I-15 mainline corridor.

Modification Restrictions for Paramics Models

Paramics allows for customization of several inputs at various levels within each model. In order to maintain the calibrated model's integrity, and to allow comparison of proposals, certain items and files within the Paramics model shall not be modified. This section documents which portions of the model may be modified and which shall not be modified.

Core Model Attributes

The core model attributes control all of the global inputs of model operation. The following section lists each entry type in version 6.5.3 and discusses modification restrictions.

- Configuration: The Contractor shall not edit any attribute within the basic nor advanced section of the configuration section.

- Vehicle Types: The Contractor shall not edit any vehicle type.
- Measurements: The Contractor may edit any of the measurements for data collection within the model.
- Categories: The Contractor shall not edit any part of any existing categories. The Contractor may add categories if necessary for a proposed design. Each added category requires documentation of its purpose and need.
- Restrictions: The Contractor shall not edit any existing restriction. The Contractor may add restrictions with documentation of its purpose, need, and location of application.
- Speed Controls: The Contractor shall not edit nor add any speed controls.

Tools

The tools section provides the Paramics user many options to view and track traffic within the network. The Contractor shall use any tool in version 6.5.3 with the following exception: the blockage removal tool. The Contractor shall not use the blockage-removal tool in any way.

Demands

The Contractor shall not edit any 2008 demands. The Contractor may use the demands as a reference for establishing future conditions and proposed designs. Refer to the Subarea trip table creation section for instructions on establishing trip tables to be used with proposed conditions.

Editor Palette

There are several functions within the Editor Palette section of Paramics. The following list summarizes each item:

- Junctions: The Contractor shall update nodes to reflect proposed design in alternative models. All remaining entries shall not be modified.
- Links: When links that have local factors applied are modified to represent a proposed design, the Contractor shall account for the total factor in the resulting link set. All remaining entries shall not be modified.
- Lane Attributes: If the Contractor proposes to close a lane, the Contractor shall apply a restriction that disallows all vehicles from the lane rather than the "Closed" check box. All remaining entries shall not be modified.
- Control Points: The Contractor shall update kerb points, stoplines and arcs to reflect proposed design in alternative models. All remaining entries shall not be modified.
- Zone Elements: To maintain correlation with the demand model, the Contractor shall not change zone position, type, or other attribute for any reason.
- Infrastructure: The Contractor may utilize infrastructure elements in models representing proposed designs.
- Public Transport: The Department did not include routes in the model. The Contractor shall not include routes in any proposed design.
- Signal Control: The Contractor may change signal control and shall document and explain any changes.

- Route Choice: The Contractor shall not utilize route choices.
- Decision Groups: The Department utilized the decision group plug-in prior to the route choice feature's inclusion in Paramics. The Contractor may utilize the plug-in and should take care to include changes in proposed design to account for the existing entries. The Contractor shall document any changes and or additions to the list of decision points. The Contractor shall not make changes to the associated **decision-groups.cfg** file.

Paramics saves the model inputs in a series of text files. The Contractor shall not edit any text file outside the Paramics graphical user interface except for the *decision-groups* file as discussed above.

Travel Demand Model Subarea Creation Instructions

This section describes the steps required to save peak period sub-area trip tables for the project study area from the I-15 travel demand model. The peak period subarea trip tables are used to develop peak hour trip tables for microsimulation analysis through Paramics. The instructions below have been written with the assumption that the user has a fully functioning version of the I-15 travel model and the user is familiar with the steps required to perform a full model run for the I-15 travel demand model. The objective of this document is to simply provide the user with the additional files and steps required to perform a subarea peak period trip table extraction for the project study area, during the course of the full model run.

Additional files

Three files (***4AssignHwy_ManagedLanes.s, 4pd_mainbody_managedlanes.block and Subarea_polygon.vpr***) have been included with this document and need to be copied into specific model subfolders as described in the next section. Other files referred to in this document (***Controlcenter.txt, HailMary_Voyager_Pre-Processing.bat, Add_to_turnpenalties_2008.txt, HailMary_Voyager_After_Pre-Processing.bat)*** should all either be available with the original model, or have equivalent files with similar filenames in the original model.

Model setup files

1. Install the I-15 travel demand model into your computer.
2. Copy the ***4AssignHwy_ManagedLanes.s*** into the folder *V60_I15\4AssignHwy\As*
3. Copy ***4pd_mainbody_managedlanes.block*** into the folder *V60_I15\4AssignHwy\As\Block*
4. Copy ***Subarea_polygon.vpr*** into the folder *V60_I15\0b_NetworkProcessing\No*
5. Create an empty folder under *V60_I15* and name it *PROJSubarea.*
6. Select the year 2008 control center file and rename it to ***Controlcenter.txt***. Modify the paths in this file to the paths in your computer.

Full model run

The steps in the procedure are as follows:

1. Run the ***HailMary_Voyager_Pre-Processing.bat*** (or equivalent) batch file.
2. Go to the folder *V60_I15\0b_NetworkProcessing\No* and append the contents of ***Add_to_turnpenalties_2008.txt*** (or equivalent file) into ***turnpenalties.txt***.
3. Open the ***Subarea_polygon.vpr*** file in the same folder as step 2. (*V60_I15\0b_NetworkProcessing\No*)
4. Go to 'Polygon->Restore->P=Expanded_newpolygon'. You should see the orange polygon in Figure 1 displaying the extents of the Expanded_newpolygon.
5. Click on 'Polygon->SubArea Extraction' and save the file into the folder *V60_I15\PROJSubarea* as ***I15_NewSubarea.net***.

6. Select the default zone numbering in the Sub-Area Extraction Node renumbering screen.
7. Run the ***HailMary_Voyager_After_Pre-Processing.bat*** (or equivalent) batch file to begin running the model.
8. The subarea matrix files (which would be used as a seed table in Paramics) are saved in the folder *PROJSubarea*.
9. Once the run is complete, the peak 3-hour AM and PM period subarea trip tables can be obtained from the folder *PROJSubarea.* These tables are the starting point for developing the peak hour trip tables for Paramics.

Post processing

The trip tables obtained at the end of step 9 are three-hour peak period trip tables for the AM and PM. To convert the trip tables to peak hour, multiply the AM and PM peak period trip tables by a factor of 0.37. This factor is consistent with what is used by the MAG model to convert the peak period trip tables to peak hour trip tables. Finally, renumber the trip table zones to match the Paramics zones.

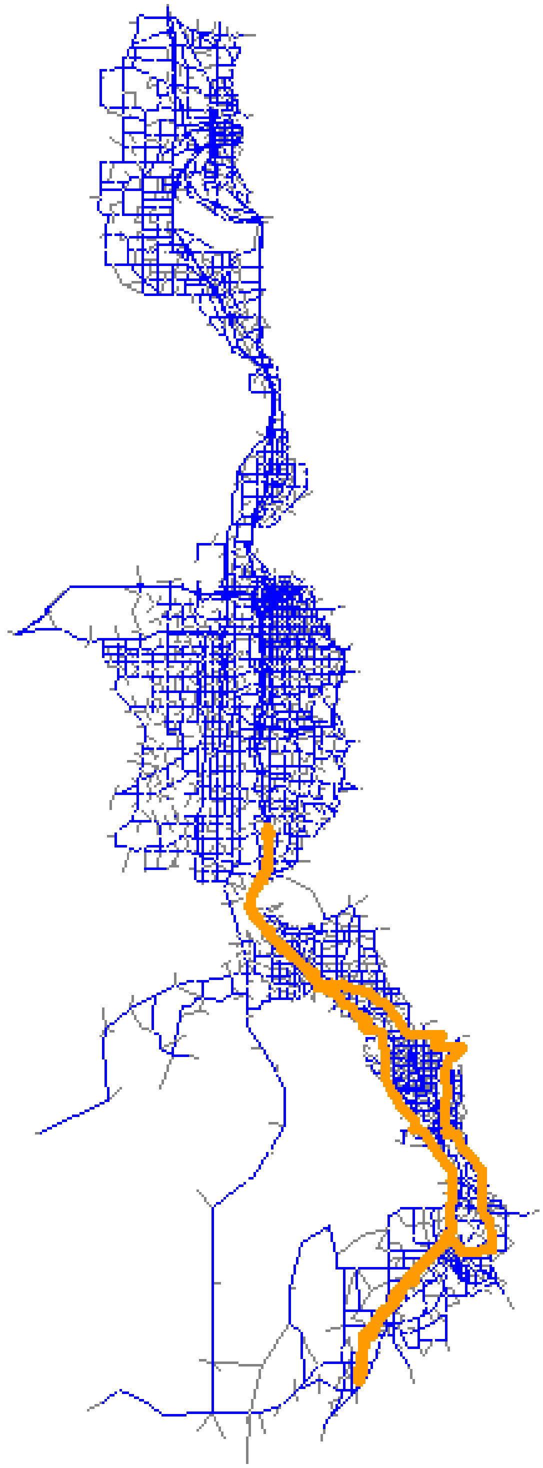

Figure 1: Network and study area polygon

Instructions for Application of HCS+

The following data and input parameters shall be used for traffic operations analyses using HCS+. These assumptions are based primarily on the prevailing local traffic conditions.

Data Sources

The Contractor shall use the data items shown in Table 8 for traffic operations analyses in HCS+, Synchro, and VISSIM:

Table 8: Data Sources of Traffic Operations Analyses

Analysis Year	Geometry	Traffic Volumes	Signal Timing
2008	The Paramics models supplied in the RFP	Table 4, Data item #1	The Paramics models supplied in the RFP
Intermediate years	As proposed	As calculated via regional TDM or Paramics	As optimized in Synchro
2030	As proposed	Table 4, Data item #1	As optimized in Synchro

Peak Hour Factor (PHF)

For existing conditions, the peak hour factor for each basic mainline segment is presented in Table 9, and these PHFs will be used for those basic freeway segments. These values were calculated using data collected in 2008. For the design year of 2030, a PHF of 0.95 is assumed.

Table 9: 2008 Mainline Peak Hour Factors

Segment	AM	PM
SR 75 to University Avenue	0.86	0.97
University Avenue to Provo Center	0.89	0.97
Provo Center to University Parkway	0.73	0.90
University Parkway to Orem Center	0.74	0.93
Orem Center to 800 N	0.76	0.90
800 N to 1600 N	0.81	0.91
1600 N to Pleasant Grove Boulevard	0.82	0.92
Pleasant Grove Boulevard to American Fork 500 E	0.95	0.97
American Fork 500 E to American Fork Main	0.91	0.96
American Fork Main to Lehi Main	0.85	0.98

Heavy Vehicle Percentage

The heavy vehicle percentage has been calculated for the peak hour for the corridor. South of Orem Center Street the value is 8% and north of Orem Center Street the value is 7%. These percentages were developed from historical data collected by UDOT Systems Planning and Programming. These truck percentages will be applied to ramp traffic as a conservative estimate of the ramp traffic composition. In addition to the truck percentage, a 2% recreational vehicle percentage will be applied to all traffic. These values shall apply in all analysis years for the Project.

Base Free Flow Speed

The base free flow speed for both the existing and design year is assumed to be 70 mph for basic mainline segments, and 35 mph for all ramps.

Number of Lanes

Express Lanes shall be treated as a separate facility by analyzing only the number of general-purpose lanes and excluding the Express Lane volume. Given the buffer separation of the Express Lane from the general-purpose traffic, this method will give an accurate operational representation of the segment. The Express Lane volumes will be determined from the Travel Demand Model. Express Lane volume is then subtracted from each mainline segment total volume. The remaining mainline volume is then averaged over the general-purpose lanes.

Adjacent Ramps

Chapter 25 of the HCM mentions the consideration of adjacent ramps. Per guidance from the HCM, a ramp is considered to be adjacent to the subject ramp if it is within the equilibrium separation distance. Also, adjacent ramps are not applicable when there are more than 4 mainline lanes.

Interchange Density

The HCM default value shall not be used for interchange density. Instead, interchange spacing will be computed over the 6-mile segment in which the basic freeway segment is located. That segment will be measured 3 miles in each direction from the midpoint of the basic freeway segment. The interchange density will then be computed by counting the number of interchanges (and parts of interchanges) within that 6-mile segment.

Terrain

The terrain is level for all segments in the study area.

Driver Population Factor

The driver population factor is 1.0 for all segments in the study area.

Determination of Ramp Analysis Needs

The Contractor shall use guidance provided on pages 25-9 and 25-10 of the HCM to govern the type of analysis performed for ramps located at either end of auxiliary lane segments. That guidance indicates that for a single-lane onramp attached to an auxiliary lane (rather than being forced to merge onto a general-purpose lane), the HCM ramp junction analysis methodology does not apply. Rather, the capacity of the freeway segment downstream of the ramp would be determined by a basic freeway segment analysis or weaving area analysis.

However, because there are so many auxiliary lanes in the 2030 Build scenario, surrogate analyses are required. These surrogate analyses will be used to assess the level of service for situations similar to the actual geometry but meeting the constraints imposed by HCM methodologies. Two examples of such surrogate analyses follow:

1. The gore-to-gore distance between an onramp and off ramp connected by an auxiliary lane exceeds the HCM weaving area limit of 2500 feet. However the segment is still short enough

(approximately 3500 feet or less) to be impacted by lane changing maneuvers. To perform a surrogate weaving analysis,

a). The weaving area length is set at 2500 feet;

b) Based on available data and/or local conditions and reasonable assumptions, the weaving volumes (ramp-to-ramp, ramp-to-mainline, mainline-to-ramp and mainline to mainline) are estimated.

Because the geometry of the surrogate is more constrained than the actual geometry, the surrogate analysis result provides a "lower bound" to the actual level of service on the freeway segment.

2. The gore-to-gore distance between an onramp and off ramp connected by an auxiliary lane exceeds the HCM weaving area limit of 2500 feet. However, it is believed that the operations of the onramp (or off ramp) are similar to those at an onramp (or off ramp) with a long acceleration (or deceleration) lane prior to merging (or diverging). To perform a surrogate ramp junction analysis, the acceleration (deceleration) lane length is set at the maximum (1500 feet), and the remainder of the ramp junction analysis proceeds as normal. Because the geometry of the surrogate is more constrained than the actual geometry, the surrogate analysis result provides a "lower bound" to the actual level of service on the freeway segment.

The Contractor shall follow guidelines similar to these in the performance of any surrogate analyses.

Instructions for Application of Synchro

Data and input parameters discussed in the section, "Instructions for Application of HCS+" shall be used when needed in Synchro modeling. For all other inputs follow generally accepted traffic engineering practice. Document any deviations from use of the assumptions presented in the HCS+ guidance or from Synchro default values.

UDOT recommends that the HCM-based reports from Synchro be the primary source for information generated by Synchro. The Contractor may use data from the "native" Synchro report for preliminary queue length information, but UDOT requires the use of VISSIM microsimulation for determination of turn bay / storage length needs.

In general, Synchro should be used to obtain signal timing settings for use in VISSIM modeling of future conditions. (Use existing signal timing for existing conditions models). Other methods for development of signal timing may be required for design concepts that fall outside Synchro's analysis capabilities.

Queuing analysis using Synchro shall use the 95th percentile queue results. When sizing storage for turning movements, the through movement queue shall also be checked to ensure that the through movement queue does not block access to the turning lane.

SimTraffic microsimulation shall not be used on the I-15 CORE Project.

Instructions for Application of VISSIM

VISSIM models shall be constructed in compliance with the *Highway Capacity Manual*. Data and input parameters discussed in the section, "Instructions for Application of HCS+" shall be used when needed in VISSIM modeling. For all other inputs use generally accepted traffic engineering practice. Document any deviations from use of the assumptions presented in the HCS+ guidance.

The CORE team will determine the level of calibration of the existing conditions (2008) models using the metrics outlined below in this section.

Provide documentation supporting the selection of the geographic area covered by each model.

For all VISSIM analyses, balanced origin-destination trip tables shall be prepared based on 2008 count data and 2030 forecasts from the travel demand model. The VISSIM analysis must include a calibration effort to ensure the model accurately replicates existing conditions at the study locations. This calibration process shall be based upon the principles contained in FHWA's Traffic Analysis Toolbox Volume III: Guidelines for Applying Traffic Microsimulation Modeling Software. The calibration targets presented in Table 4, Chapter 5 of this document shall be used for the calibration of the existing conditions models.

Existing conditions models shall be calibrated using 2008 travel time (Table 4, data item #6) and / or volume data (Table 4, data item #3). These Measures of Effectiveness (MOEs) shall also used to estimate the minimum number of simulation runs that are required to obtain a sample that adequately represents the traffic conditions. The model shall be run enough times so that the confidence interval of the MOE from the model runs falls within the desired confidence interval with a 95% level of confidence. Since models for different areas may have different requirements, I-15 CORE traffic personnel shall be consulted as to which MOE to use and the size of the desired confidence interval. The formula below shall be used to estimate the minimum number of simulations:

$$CI_{1-\alpha\%} = 2 * t_{(1-\alpha/2),N-1} \frac{s}{\sqrt{N}}$$

where:

$CI_{1-\alpha\%}$ = (1-α)% confidence interval for the true mean, where α equals the probability of the true mean not lying within the confidence interval

$t_{(1-\alpha/2),N-1}$ = Student's t-statistic for the probability of a two-sided error summing to α with N-1 degrees of freedom, where N equals the number of repetitions

s = standard deviation of the model results

To estimate the number of runs, the Contractor shall run the model a minimum of four times in order to calculate the standard deviation of the MOE that would be entered into the formula above. The confidence interval shall then be calculated to determine if it falls within the desired confidence level.

Where appropriate, hypothesis testing may be used to compare design concepts. The purpose for these tests is to determine with a 95% level of confidence that one concept is better than another. The following hypotheses shall be used:

H_0: $\mu_1 - \mu_2 = 0$

H_A: $\mu_1 - \mu_2 \neq 0$

where:

μ_1 = mean MOE of alternative design concept 1

μ_2 = mean MOE of alternative design concept 2

Collect metrics to report from VISSIM modeling in compliance with the *Highway Capacity Manual*. Metrics to report from VISSIM modeling results include the following:

- From the link evaluation (for mainline, ramps, ramp junctions, and arterial analysis):
    - Density

  - Speed
  - Percentage of demand served
  - Number of vehicles served
- From the node evaluation (for intersections and ramp meters):
  - Average control delay per vehicle
  - Percentage of demand served
  - Number of vehicles served
  - Average queue
  - Maximum queue

When computing level of service from VISSIM output, utilize Exhibits 16-2 and 23-2 from the *Highway Capacity Manual* to convert average control delay per vehicle and density to LOS.

Queuing analysis shall use 95% of the maximum queue from the VISSIM modeling results. When sizing storage for turning movements, the through movement queue shall also be checked to ensure that the through movement queue does not block access to the turning lane.